

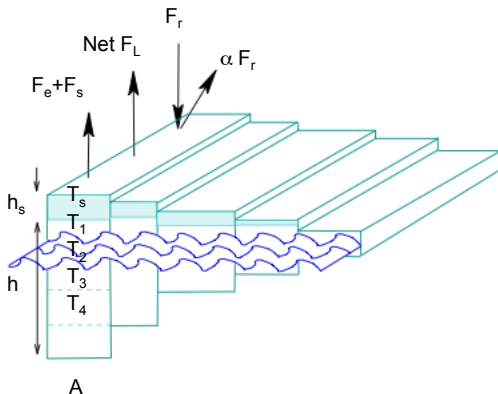
State of the Art in GCMs: The Ice-Ocean Interface

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Ice Thickness Distribution g

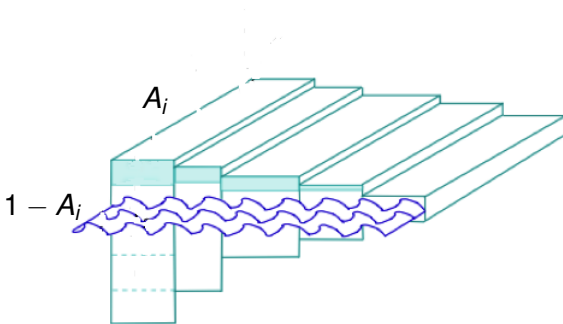
Schematic of model representation of $g(H)$ in five ice “categories”



A =fractional coverage of a category

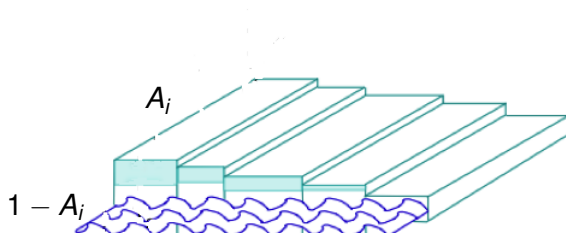
Ice Thickness Distribution g

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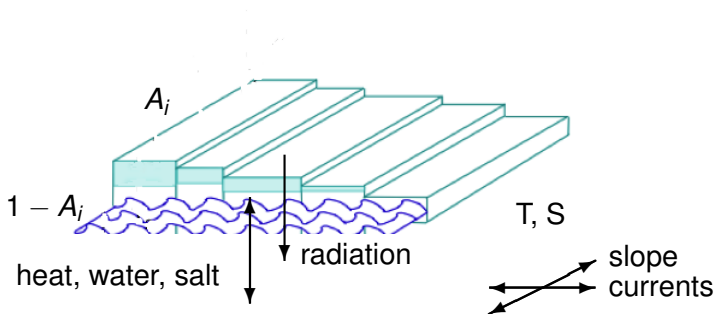
Ice Thickness Distribution g

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Ice Thickness Distribution g

Schematic of model representation of $g(H)$ in five ice “categories”



Typical coupling fields

ocn \rightarrow ice

sst	sea surface temperature
sss	sea surface salinity $T_f = -1.8^\circ\text{C}$ $T_f(\text{sss})$
frzmlt	freezing/melting potential $\text{frzmlt} \propto c_p \rho_w (T_f - \text{sst})$ $\text{frzmlt} < 0 \Rightarrow \text{ice melt}$ $\text{frzmlt} > 0 \Rightarrow \text{frazil ice formation}$
$(\frac{\partial H}{\partial x}, \frac{\partial H}{\partial y})$	surface slope
(u_w, v_w)	surface current (for ocean-ice stress)

Typical coupling fields

ice \rightarrow ocn

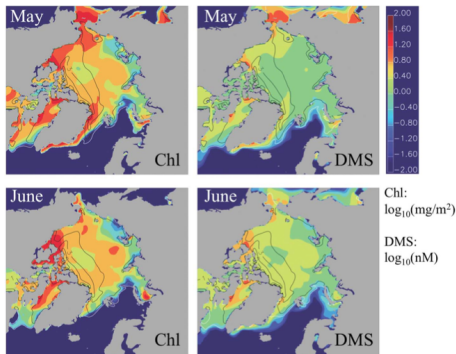
(τ_x, τ_y)	ice-ocean stress $(\tau_x, \tau_y) = -\vec{\tau}_w = -\text{drag coef} \times \text{quadratic } f(\vec{u}_w - \vec{u}_i)$ $(\tau_x, \tau_y) = \vec{\tau}_a + \nabla \cdot \sigma$
A_i	ice area fraction
F_{swthru}	penetrating shortwave
F_{hocn}	surplus heat $F_{hocn} \leq -\text{frzmlt}$ heat used: $F_{bot} = -\rho_w c_w c_h u_* (T_w - T_f)$, $u_* = \sqrt{\frac{ \vec{\tau}_w }{\rho_w}}$
F_{fresh}	fresh water
F_{salt}	salt <i>virtual fluxes: Assume constant sss, S_i</i> <i>considerations for 'real' fluxes:</i> scaled vertical coordinates (z^* , p^*) sea ice can melt/freezing at depth

Other coupling fields

Biogeochemical fluxes are starting to appear in GCMs

- aerosols are in CESM sea ice but not fluxed to ocean
- sea ice BGC models are in development

Chlorophyll & DMS produced by CICE algae:
Pigments in ice, trace gas below and in margins



S. Elliott, C. Deal, G. Humphries, E. Hunke, N. Jeffery, M. Jin, M. Levasseur, and J. Stefels (2012). Pan-Arctic simulation of coupled nutrient-sulfur cycling due to sea ice biology. JGR, doi:10.1029/2011JG001649.

Other issues

Coupling period

- resolve diurnal cycle, inertial period, waves, etc
- apparent instability
- treatment of Coriolis term

Surface roughness

- ice: melting
- ocean: stirring
- parameterize based on ridged ice fraction?

<your suggestions here>